WINTER-15 EXAMINATION

Model Answer

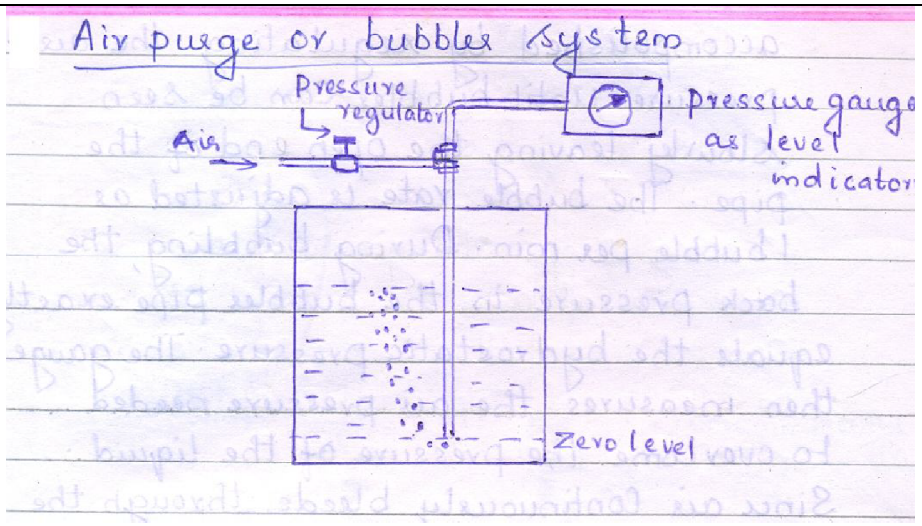
Important Instructions to examiners:

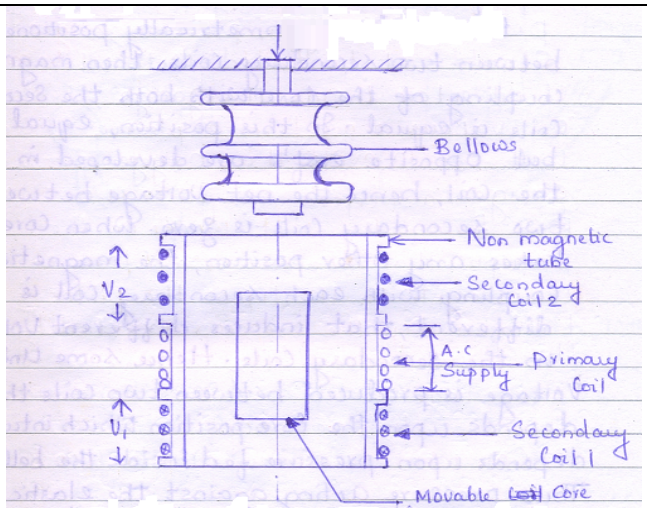
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

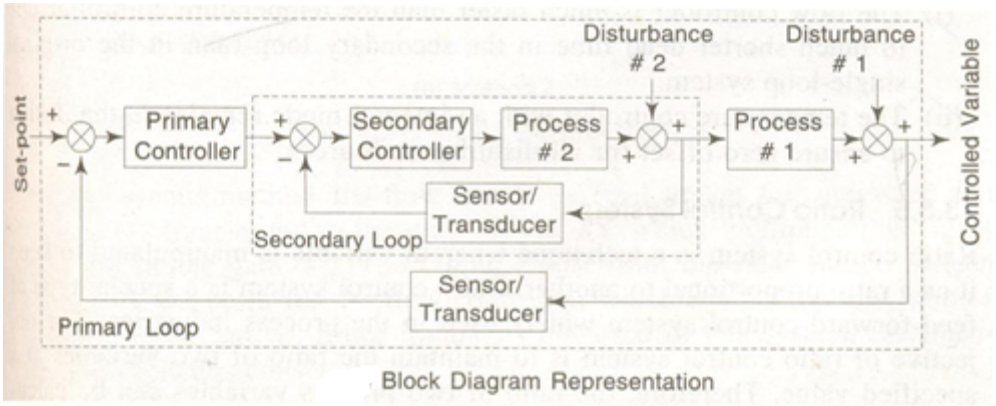
<table>
<tr><th>Q No.</th><th>Answer</th><th>marks</th><th>Total marks</th></tr>
<tr><td>1A</td><td>Attempt any three</td><td></td><td>12</td></tr>
<tr><td>1A-a</td><td>Definition:
Static characteristics: Static characteristics are those that must be considered when the instrument is used to measure a condition not varying with time.
Dynamic characteristics: Dynamic characteristics are those that must be considered when the instrument is used to measure a condition varying with time.</td><td>2

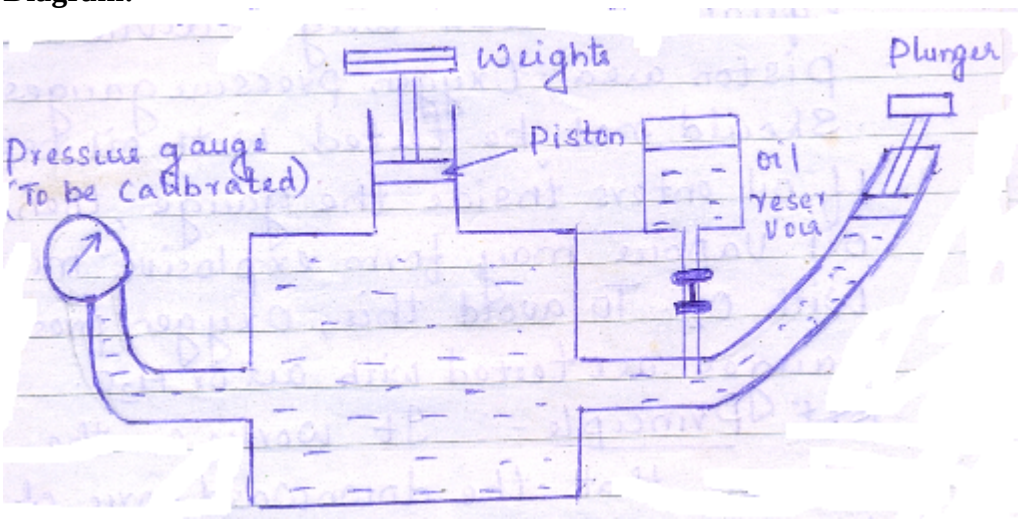
2</td><td>4</td></tr>
<tr><td>1A-b</td><td>Different temperature scales
1.Centigrade or Celsius
2. Kelvin
3. Fahrenheit
4. Rankine,
5. Reaumur
<table>
<tr><th>Temperature scale</th><th>Ice point</th><th>Steam point</th></tr>
<tr><td>Centigrade or Celsius</td><td>0^oC</td><td>100^oC</td></tr>
<tr><td>Kelvin</td><td>273K</td><td>373K</td></tr>
<tr><td>Fahrenheit</td><td>32^oF</td><td>212^oF</td></tr>
<tr><td>Rankine</td><td>491.69^oR[1]</td><td>$671.69\ ^oR$[1]</td></tr>
<tr><td>Reaumur</td><td>0^oR</td><td>80^oR</td></tr>
</table></td><td>½ marks eachfor any four.

½ marks each for any four.</td><td>4</td></tr>
</table>

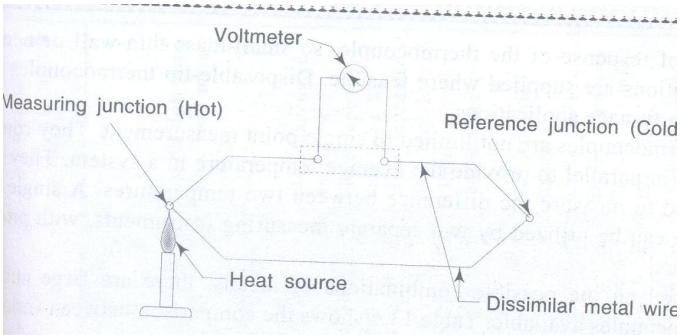
1A-c	 **Methods for indirect level measurement(any four):** Pressure gauge, air purge radioactive, ultrasonic,capacitive	2 ½ marks each for any four.	4
1A-d	**Classification of flow meter:** flowmeters are classified into A. Inferential flow meters: 1) Differential pressure meters(head meter) 2) Variable area meter 3) Electromagnetic flow meter 4) Velocity flow meter 5) Ultrasonic flow meters B. Quantity flow meters: 1) Mass flow meter **2)** Positive displacement flow meter.	4	4
1B	**Attempt any one**		**6**
1B-a	**LVDT** **Diagram:**		6

	 **Working** When the pressure insidethe bellows changes, its free end gets deflected along with the movable core.When the core is symmetrically positioned between the two secondary coils, themagnetic coupling of the core with both the secondary coils is equal. In thisposition, equal but opposite emfs are developed in the coil, and hence the netvoltage between two secondary coils is zero. When core takes any other position,the magnetic coupling with each secondary coil is different, that induces differentvoltages in the secondary coils. Hence some unbalance voltage is producedbetween the coils that depends upon the position of the core which in turndepends upon the pressure fed inside the bellows. Thus it converts the displacement due to the pressure applied into an electrical signal.	3 3	
1B-b	**Cascade control system**		6

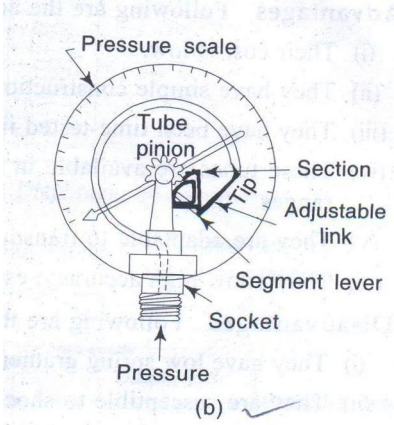
	Block diagram:  Block Diagram Representation **Description:** In a cascade control system, there is one manipulated variable and more than one measurement. It employs 2 feedback controllers, with the output of the master (primary) controller changing the set point of the slave (or secondary) controller. It eliminates the effect of disturbances and improves the dynamic response of control loop. The feedback controller attempts to maintain the process variable at its set point in response to all the disturbances and ensures zero steady state offset for step like disturbances. Cascade control system considers the likely disturbances and tune the control system to the disturbances that strongly degrades the performance. It uses an additional secondary measured process input variable that has the important characteristics of indicating occurrence of the key disturbances.	3 3	
2	**Attempt any four**		**16**
2-a	**Difference between Open loop and closed loop control system:** Sr No. | **Open loop control system** | **Closed loop control system** 1 | Feedback doesn't exists | Feedback exists 2 | Output measurement is not | Output measurement is	1 mark each for any four.	4

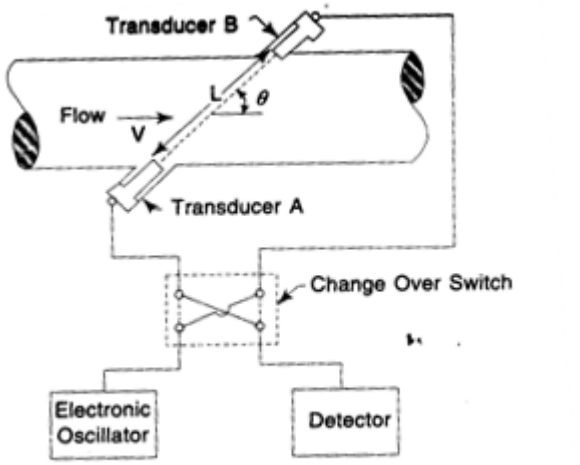
			necessary	necessary			
		3	Any change in output has no effect on input	Changes in output affects the input			
		4	Error detector is absent	Error detector is present			
		5	Inaccurate and unreliable	Highly accurate and reliable			
		6	Highly sensitive to disturbance	Less sensitive to disturbance			
		7	Highly sensitive to environmental changes	Less sensitive to environmental changes			
		8	Simple in construction and cheap	Complicated in construction and hence costly			
		9	Highly affected by non-linearities	Reduced effect of non-linearity			
2-b	**Dead weight tester:** **Diagram:**  **Working:** It consists of a cylinder with piston, displacement pump to suck the oil from the					2	4

	reservoir on upward stroke and pressurize the oil on downward stroke and the gauge to be tested. At the top of the piston, there is a platform on which standardknown weights are placed. The weight pressurizes the oil into pressure gauge.The pressure in the tester is build up till the weights are seemed to float, whenthe fluid gauge pressure equals the dead weight divided by piston area.	2	
2-c	**Function of valve positioner:** When static frictional forces are large, valve positioner is used along with actuator so as to correctly position the valve stem in response to the control signal. Valve positioner improves the speed of response and reduces the hysteresis effect. **Function of valve actuator:** it is that portion of the valve that responds to the applied signal and results in the movement of the stem due to which the flow rate of fluid changes.	2 2	4
2-d	**Functions of Computer aided Process Control System: following are the functions.** 1) Measurement and data acquisition 2) Data conversion with scaling and checking 3) Data accumulation and formatting 4) Visual display 5) Comparing with limits and alarm raising 6) Recording and monitoring of events, sequence and trends 7) Data logging and computation **8)** Control action	1 mark each for any four.	4
2-e	**Application of PLC:** 1) PLC can be a vital part of industrial automation as it produces on/off voltage outputs to actuate elements such as electric motors, solenoids etc.	2	4

	2) It can also be used in sequential controllers used for periodical on/off of fans, heaters and light switches. **Application Of DCS:** 1) DCS are designed for continuous process where the control signal is analog rather than discrete. 2) It is a powerful integrated control system having capabilities such as, data acquisition, advanced process control and batch control capabilities for various industrial environments such as cement factory, oil refinery, power plant etc.	2	
2-f	**Importance of valve sizing:** Valve sizing is important for using the appropriate size valve for various applications. For a fixed flow rate, ideal valve will be the one that will function between 40% and 70% of thefull operating range so that for maximum flow, it is not wide open and for minimum flownot closing down too near its seated position. For handling liquids with low flash point, oversize valves are normally employed. Foe valve sizing, the maximum flow consideredshould be the required maximum flow and not the full capacity of the valve.	4	4
3	**Attempt any four**		16
3-a	**Thermocouple** **Diagram**  	2	4

<table>
<tr><td></td><td>Working:
The working principle of a thermocouple depends on the thermo-electric effect. If two dissimilar metals are joined together so as to form a closed circuit, there will be two junctions where they meet each other.If one of these junctions is heated, then, a current flows in the circuit which can be detected by a galvanometer.The amount of the current produced depends on the difference in temperaturebetween the two junctions and on the characteristicsof the two metals.This was first observed by Seebeck in 1821 and is known as Seebeck effect.</td><td>2</td><td></td></tr>
<tr><td>3-b</td><td>Difference between direct and indirect level measurement
<table>
<tr><th>SR. NO.</th><th>DIRECT LEVEL MEASUREMENT</th><th>INDIRECT LEVEL MEASUREMENT</th></tr>
<tr><td>1</td><td>Simple method of measuring liquid level</td><td>Complex method of measurin liquid level</td></tr>
<tr><td>2</td><td>Ex. 1) Hook type level indicator
2) Sight glass
3) Float type</td><td>Ex. 1) hydrostatic pressure typ
2) Electrical method</td></tr>
</table></td><td>2 marks each</td><td>4</td></tr>
<tr><td>3-c</td><td>Elastic pressure transducer:
In Elastic pressure transducers use elastic primary sensing element such as the bourdon tube, bellows, and diaphragm that converts pressure in to proportional mechanical displacement.
Bourdon tube for pressure measurement.</td><td>1</td><td>4</td></tr>
</table>

	 As the fluid under pressure enters the bourdon tube, it tries to change the section of tube from oval to circular, and this tend to straighten out the tube The resulting movement of the free end of the tube causes the pointer to move over the scale. The tip of the bourdon tube is connected to a segmental lever through an adjustable length link. The lever length also is adjustable. The segmental lever end on the segment side is provided with a rack which meshes to a suitable pinion mounted on spindle. The segmental lever is suitably pivoted and the spindle holds the pointer. A hairspring is sometimes used to fasten the spindle to the frame of the instrument to provide the necessary tension for proper meshing of the gear teeth,thereby freeing the system from backlash. Bourdon tubes are made from materials such as phosphor bronze, alloy steel, stainless steel, monel metal, and beryllium copper.	3	
3-d	**Ultrasonic flow meter** **Diagram**		4



Time-difference Type Ultrasonic Flowmeter.

2

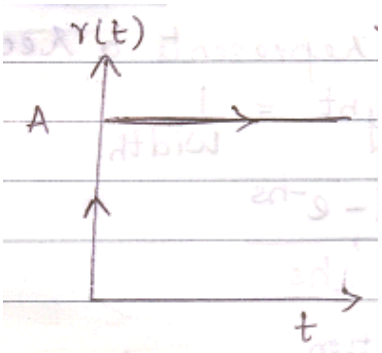
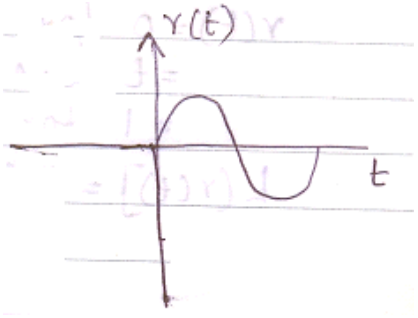
Working:

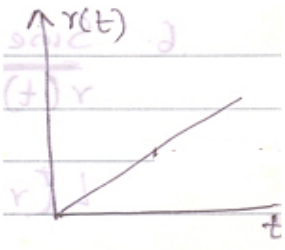
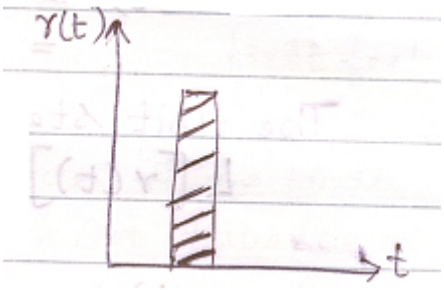
In ultrasonic flow meters, the measurement of flow rate is determined by the variation in parameters of ultrasonic oscillations

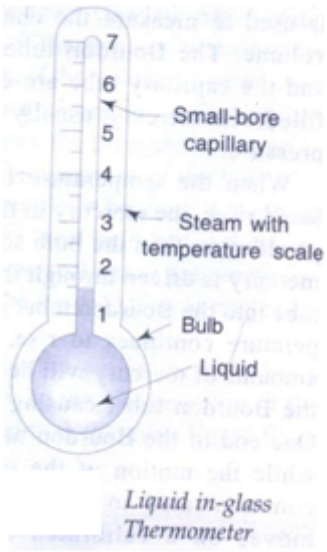
Time Difference Type ultrasonic flow meters measure flow by measuring the time taken for ultrasonic wave to transverse a pipe section, both with and against the flow of liquid within the pipe. It consists of two transducers, A and B, inserted into a pipe line, and working both as transmitter and receiver, as shown in Fig.. The ultrasonic waves are transmitted from transducer A to transducer B and vice versa. An electronic oscillator is connected to supply ultrasonic waves alternately to A or B which is working as transmitter through a changeover switch, when the detector is connected simultaneously to B or A which is working as receiver. The detector measures the transit time from upstream to downstream transducers and vice versa.

2

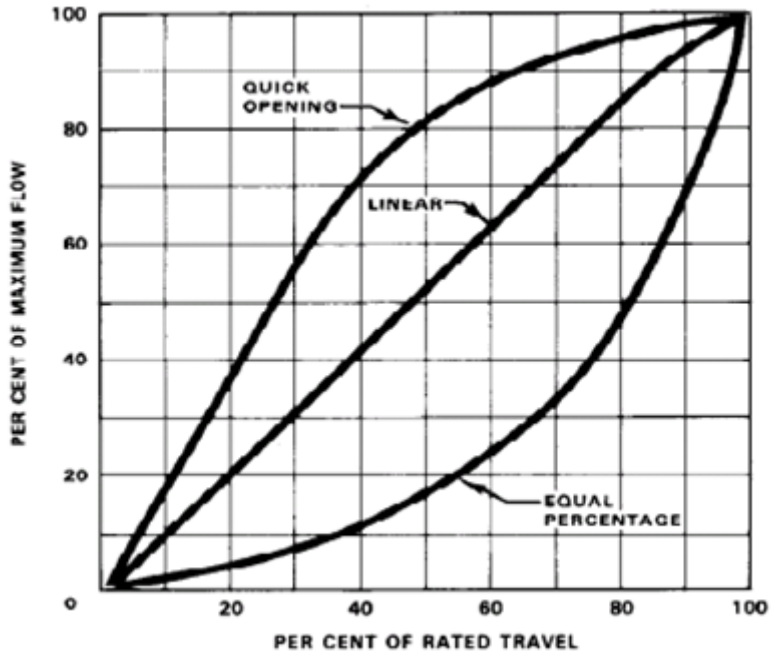
The time T_{AB} for ultrasonic wave to travel from transducer A to transducer B is given by the expression:

	$$T_{AB} = \frac{L}{(C + V\cos\theta)}$$ and, the time (T_{BA}) to travel from B to A is given as, $$T_{BA} = \frac{L}{(C - V\cos\theta)}$$ where, L = the acoustic path length between A and B, C = velocity of sound in the fluid, θ = angle of path with respect to the pipe axis, V = velocity of fluid in pipe. The time difference between T_{AB} and T_{BA} can be calculated as, $$\Delta T = T_{AB} - T_{BA} = \frac{2LV\cos\theta}{C}$$ $V=\Delta TC/2L\cos\theta$		
3-e	**System input for** **i)Step :**  **ii)Sinusoidal :**  **iii)Ramp :**	1 mark each	4

	 **iv)Pulse:** 		
4	**Attempt any three**		**12**
4A-a	**Pyrometer:** **Definition :** Pyrometer is a non-contactable technique for measuring temperature. Pyrometer is a technique for determining a body's temperature by measuring its electromagnetic radiation. **Principle of radiation pyrometer:** Every material other than inert gashaving temperature above absolute zero has a universal property of emitting thermal radiations. According to Stefan Boltzmann's law, the intensity of radiant energy emitted by a hot target varies as the fourth power of its absolute temperature. $\Phi_b = \sigma A T^4$ σ –Stefan Boltzmann constant. T – Absolute temperature. A - Area Operation of radiation pyrometer is based upon the measurement of radiant	1 3	4

	energy emitted by the hot body.		
4A-b	**Glass thermometer**: **Principle:** Its operation is based on the fact that liquid expands as the temperature rises. **Diagram :**  *Liquid in-glass Thermometer* **Working:** Glass Thermometer consist of a small bore tube with a thin wall glass bulb at its lower end. The liquid that fills the bulb and part of the tube is mercury. As heat is transferred through the well and metal stem and into the mercury, the mercury expands, pushing the column of mercury higher in the capillary above which indicates the temperature. The liquid in glass thermometer is commonly used for the temperature range of – 18.4 to 608 °F (-120 to 320° c).	1 2 1	4
4A-c	**Advantages of head flow meters over other flow meters** 1. Low cost for larger pipes.	1 mark each for any four	4

	2. Wide application 3. Accurate and reliable 4. Easily removed without shutting down the process. **5.** Adaptable to any pipe size and flow rate.	points.	
4A-d	**Principle of mass flow meter:** A mass flow meter, also known as an inertial flow meter is a device that measures mass flow rate of a fluid traveling through a tube. The mass flow rate is the mass of the fluid traveling past a fixed point per unit time. The mass flow meter does not measure the volume per unit time (e.g., cubic meters per second) passing through the device; it measures the mass per unit time (e.g., kilograms per second) flowing through the device. **Advantages of Thermal Flow meter(any two)** 1. No temperature or pressure compensation required. 2. Linear output (as temperature differential is proportional to mass flow). 3. Can be used on corrosive process streams if proper materials are specified. 4. DC voltage or 4 to 20 mA dc outputs available.	2 1 mark each	4
4B	**Attempt any one**		**6**
4B-a	**Valve Characteristics:** The relation between stem position, plug position and rate of flow is described in terms of flow characteristics of valve. Two types of valve characteristics are there –Inherent and Installed or effective.	\	6



Inherent flow characteristics are plotted when constant pressure drop is maintained across the valve. There are two different inherent flow characteristics- linear and equal percent.

Linear Opening characteristics: Linear characteristics valve has linear relation between valve opening and flow rate at constant pressure drop

Q = by

Q- Flow rate at constant pressure drop

b - constant

y - valve opening / valve stem travel

Generally used

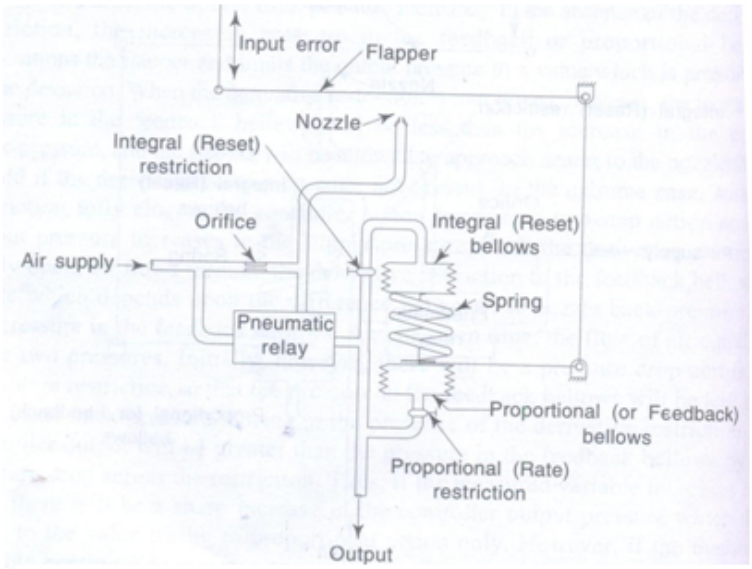
- For slow process
- When more than 40% of the system pressure drop occurs across the valve.

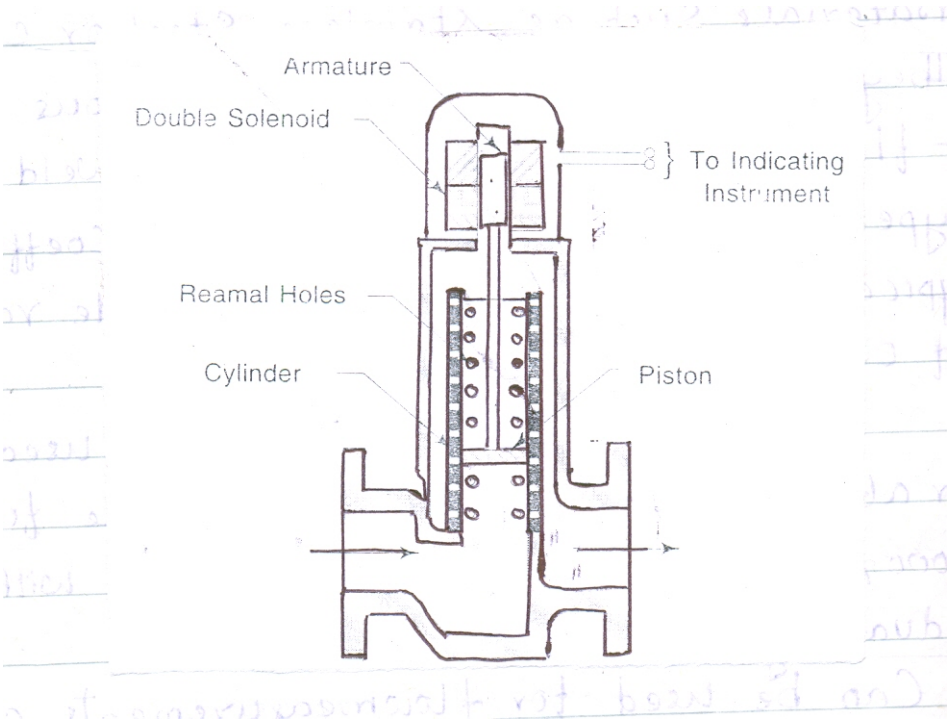
Equal Percentage characteristics: In equal percentage valve equal increment

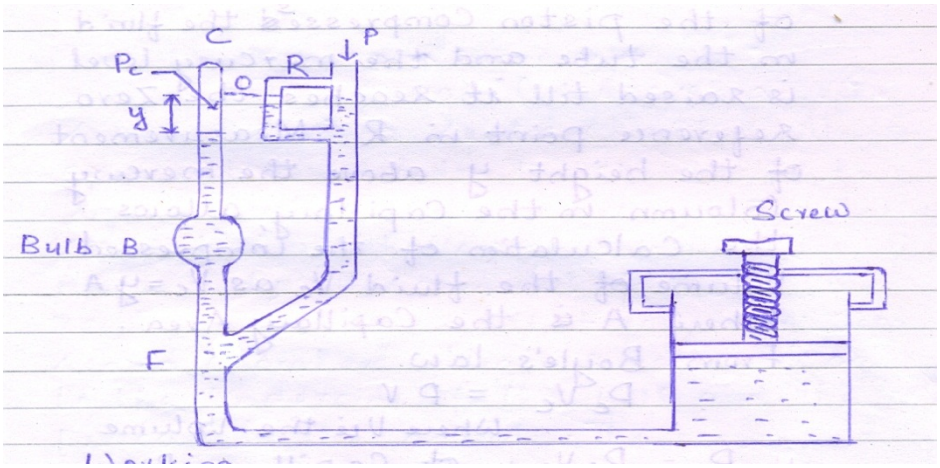
2

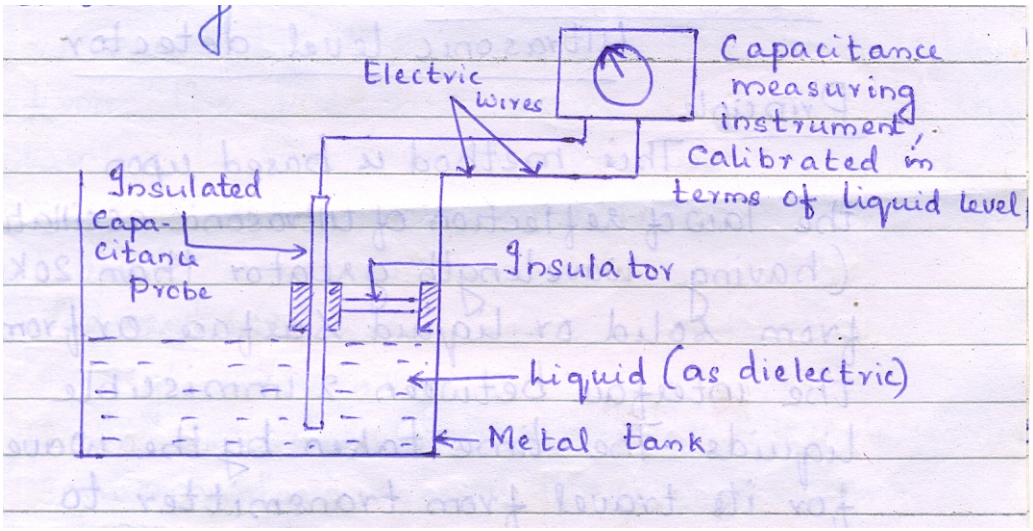
4

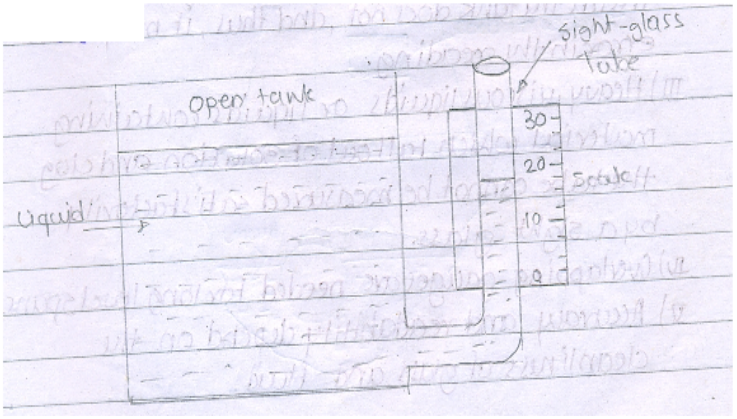
	of the stem travels give equal % change of the existing flow $Q = be^{ay}$ Q= Flow rate at constant pressure drop a& b = constant e = base of natural logarithms y = valve opening / valve stem travel Generally used • For fast processes • When high rangeability is required At heat exchangers where an increase in product rate requires much greater increase in heatingand cooling medium. **Installed flow characteristics**are plottedwhen the differential pressure across the valve changes. **Quick opening** – In this there is maximum flow for minimum travel It is approximately linear when the flow rate is less but beyond 30% the flow increases rapidly with valve opening It gives approximately 90% flow at 30% travel • For on – off control When maximum valve capacity must be obtained quickly.		
4B-b	**PID controller** **Diagram**		6

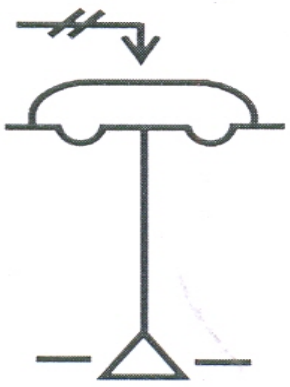
	 **Description:** Pneumatic PID controller are made of Pneumatic flapper nozzle which is a displacement type pneumatic detector. It has been seen that the rate action can be obtained by causing the feedback pressure to lag the output pressure and reset action can be obtained by use of positive feedback pressure which lags the output while the negative feedback pressure is the same as the output pressure. By causing both the positive and the negative feedback to lag the output pressure, both rate and reset action may be obtained which is known as proportional plus integral plus derivative controller as shown in fig above.	3 3	
5	**Attempt any four**		**16**
5-a	**Flow meter for high viscosity fluid material:** Cylinder and piston type flow meter **Diagram:**	1	4

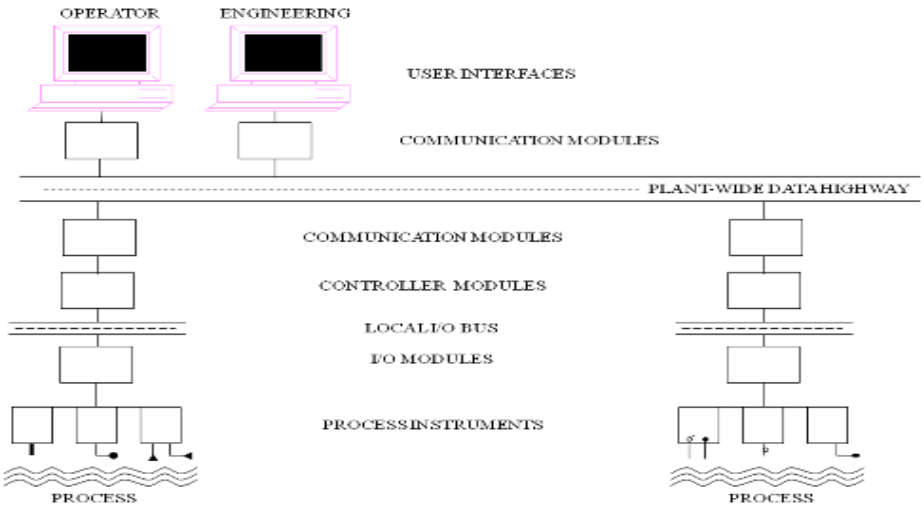
	 **Construction:** It consists of a cylinder and a piston fitted into it. A series of reamed holes are provided in the walls of the cylinder to provide passage for fluid flow. These holes are spaced helically around the cylinder in rows to provide a continuous variation in area for various heights if the piston.	1½ marks 1½ marks	
5-b	**Principle of pressure gauge:** Pressure gauge works on hydrostatic principle. When liquid is held in a tank, then it exerts equal pressure on the walls of the tank. Such a pressure is due to the weight of liquid present above a certain reference point or base and is called hydrostatic head or pressure. **Disadvantages:** 1) Low spring gradient	2 1 mark each for	4

	2) Susceptible to shock and vibration **3)** Large hysteresis effect	any 2	
5-c	McLeod gauge is used for measuring pressure in the range of 10^{-1} to 10^{-5} torr. **Diagram:**  **Working:** To operate the gauge, the piston is first withdrawn, causing the level of mercury in the lower part of the gauge to fall below the level of the junction between the two tubes. The unknown pressure source is connected to the gauge from where it also flows and fills the bulb and capillary. Next, the piston is pushed in, moving the mercury level up to block the junction. At this stage,, the fluid in the capillary and the bulb is at pressure P. Further movement of the piston compresses the fluid in the tube and the mercury level is raised till it reaches the zero reference point in R. Measurement of the height above the mercury column in the capillary allows the calculation of the compressed volume of the fluid. The expression for calculating the unknown pressure is $P = A\rho g y^2 / V$ Where A is capillary area	1 1½ marks 1½ marks	4

	ρ is density of fluid y is height above the mercury column in capillary		
5-d	**Measurement of solid level :** **Capacitance level detector** **Diagram**  **Construction & Working:** It consists of two conductors separated from each other by dielectric material between them. There is an insulated capacitance probe fixed near and parallel to tank wall such that the probe and metal tank wall acts as conductors with conducting solids as the dielectric medium. These two conductors are connected to capacitance detecting element. As the solid level changes, the dielectric constant changes due to which capacitance changes. Thus any change in solid level can be measured in terms of change in capacitance. ***(Marks may be given for ultrasonic method or radiation method)***	2 2	4
5-e	**Sight glass method:** **Diagram:**		4

	 **Construction:** Sight glass instrument consists of graduated tube of toughened glass which is connected to the exterior of the tank at the bottom. The liquid level in the sight glass matches the level of liquid in the tank.	2 2	
6	**Attempt any Two**		**16**
6-a	**Control actions:** The 4 basic control action are, 1. On-Off or Two position control action $m=M_1$ for $e>0$ $m=M_2$ for $e<0$ m – output , e - error 2. Proportional (P)controller $m=K_P e$ Kp – proportional gain 3.Integral (I)or reset action $m = \frac{1}{T_i}\int_0^t e dt$ Ti – integral time	1½ marks 1½ marks 1½ marks	8

	4. Derivative (D)or Rate controller $M=T_d\ de/dt$ Td – derivative time **Reason for D controller being not used alone:** The derivative mode cannot, by itself, control a process. One reason for this isthat a constant or no deviation from the set point makes the above expression equal to zero. As well, if a sudden change in the process variable occurs, an infinite signal is sent to the controller, which causes the relevant mechanical apparatus to fully open or close. This leads to an unending instability.	1½ marks 2	
6-b	**Working of air to open control valve:**  They are control valves operated through pneumatic actuators. It is designed in such a way that if the air supply fails, the control valve will be fully closed for safety requirement of the process. **Application**: Used in situations where, the valve is used to control steam or fuel flow, the valve should be completely shut off in case of air failure. **Working of air to close control valve:**	2 2	8

	 It is designed in such a way that if the air supply fails, the control valve will be fully open for safety requirement of the process. **Application:** Used in applications where**,** the valve is handling cooling water to a reactor, the flow should be maximum in case of an emergency.	2 2	
6-c	**Distributed control system**  In DCS equipment is separated in functional area and is installed in different work areas of a process plant. The plant operator monitors and manipulates the set-points of the process parameter from central control room. Controlling portion of the DCS, distributed at various location performs following two function at each location	4 4	8

	1. Measurement of analog variable and discrete inputs 2. Generation of output signals to actuators that can change process condition In Figure above the operator console in the conrol room is connected through a data highway to several distributed system components. A DCS consist of the following modules: 1 Operator stations that use microprocessor based CRT display and keyboard communication with control device and displays 2 Remote multifunction microprocessor based controllers (PLCs) 3 A digital data link (data highway) that connects the multifunction controllers with the central operator stations. The first priority of DCS is to provide operator interfacing and real time process control. DCS has flexibility of implementation of sequential control and integration among the various types of control.		